Re-entrant Orbital Order

Scientific Achievement

Conductivity, magnetization and neutron and x-ray diffraction data for the layered manganite $La_{2-2x}Sr_{1+2x}Mn_2O_7$ (x~0.5) are consistent with the CE-type orbital/charge order being the zero-temperature ground state, but only for a very narrow range of x, presumably at exactly 0.5. Deviations from x=0.5 lead to re-entrance, in which CE-order loses out to an A-type antiferromagnet at low temperatures or, for larger deviations, a complete lack of CE-order at any temperature. This data suggests how the detailed phase diagram of this important class of manganites may look (see figure). Data for x~0.6 confirm the bistripe (BIS) orbital/charge order state with a similar reentrance, but we have not as yet found if it is the ground state for exactly 0.6.

Open questions include the extent of charge delocalization for nearby ground states that do not exhibit CE order. Neither the specific orbital order nor magnetic structure of the BIS state are known. An understanding of the physical basis of re-entrance will likely require including the effects of the order/disorder of the various states (entropy) in a thermodynamic description.

Significance

Strongly correlated electron systems are at the heart of condensed matter research. Especially in transition metal oxides they lead to exotic phases, phase transitions and a wealth of potential device applications such as spintronics, which uses the spin as well as charge of the electron to process, transmit and store information. Electronic conduction and the nature and occurrence of localized states are of paramount importance. The layered manganites offer some advantages for establishing trends that may be generalized to other systems, including a strong intrinsic coupling of spin degrees of freedom to transport and phase stability.

Performers

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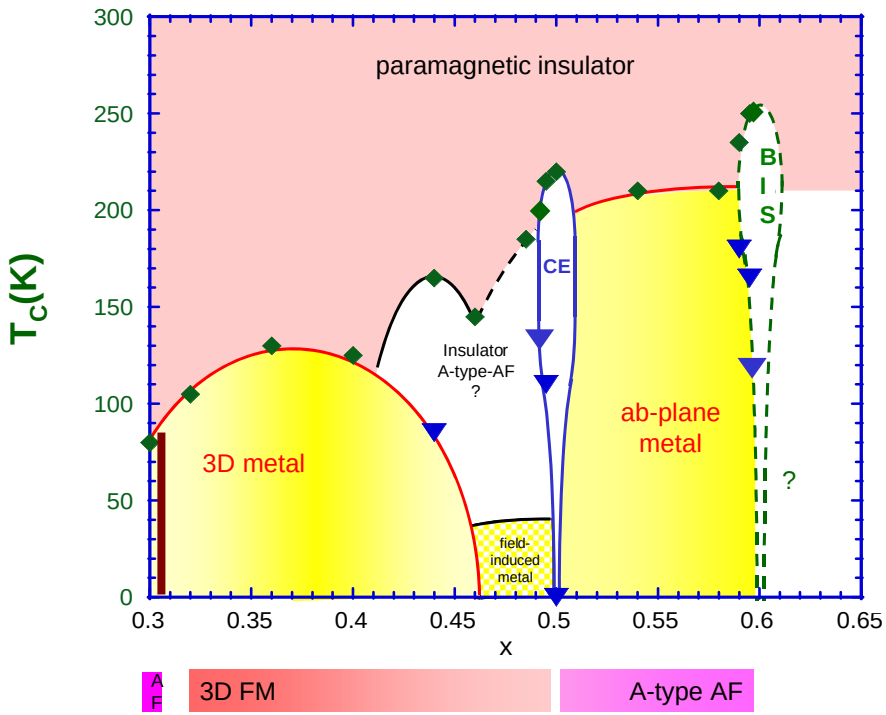
What We Have Learned



Preliminary phase diagram for bilayer manganites showing re-entrant CE and bi-stripe (BIS) orbital order for compositions, x, slightly different from commensurate 0.5 and 0.6.

Open Questions

Physical understanding of re-entrance for orbital/charge ordered states?

Are states next to CE order ab-plane metals for x>0.5 and insulators for x<0.5?

What is ground state for precisely x=0.6?
What is the magnetic order of the BIS state?

For x~0.46, why are the A-type AF states insulating when theory predicts and data confirm (for x>0.5) that these states are ab-plane metals?

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